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Adverse neonatal outcomes and house prices in London

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ABSTRACT

Aim

To explore whether the average price of houses per postcode sector (SHAP) can be utilised as an index of socioeconomic deprivation and whether gestational age would be lower and mortality higher in the least expensive areas compared to the most expensive.

Methods

All neonatal unit admissions at King's College Hospital from 1/1/2012 to 31/12/2016 were reviewed. The SHAP was retrieved from the Land Registry and the population was divided in equal quintiles with quintiles one and five representing the most and least expensive areas respectively. Gestational age and birth weight z-score were collected. Mortality was defined as death before discharge from neonatal care.

Results

Three thousand three hundred and sixty infants were included and divided in quintiles consisting of 672 infants. Gestational age was lower in quintile five compared to all other quintiles (adjusted $p < 0.001$). Birthweight z-score was not significantly different between the quintiles. The SHAP was lower in the infants who died before discharge ($n=92$) compared to the SHAP of the infants who were alive at discharge ($n=3268$) (adjusted $p < 0.001$).

Conclusions

Low sector house average prices (SHAP) were associated with poorer perinatal outcomes suggesting SHAP can be used in perinatal populations to determine socio-economic status and associated outcomes.

KEY WORDS

Deprivation

House prices

Low birthweight

Mortality

Prematurity

Socioeconomic

INTRODUCTION

Low socioeconomic status has been associated with adverse perinatal outcomes such as premature birth, low birth weight and neonatal mortality [1]. In the United Kingdom, infants from the most deprived quintile of the population have an odds ratio of 1.72 for premature birth before 32 weeks of gestation, 1.81 for low birthweight below 2.5kg and 1.61 for neonatal mortality compared to the infants of the least deprived quintile [1]. The reasons for such large socioeconomic disparities in such key pregnancy outcomes are not completely understood, but are thought to be related to maternal nutrition [2], maternal smoking [3], use of alcohol and drugs [2], access to prenatal care [4], maternal infection [5] and psychosocial factors such as maternal stress [6]. A growing body of evidence suggests that prematurity and low birth weight are associated with chronic adult diseases such as hypertension and type 2 diabetes [7, 8].

Previous epidemiological studies in the UK have utilised three deprivation indices to assess the socioeconomic status: the Townsend index [9], the Carstairs index [10] and the UK index of multiple deprivation [11]. The Townsend and Carstairs indices which are similar ones utilised in England and Scotland respectively). They are based on 10-yearly Census data and take into account a number of factors including unemployment, non-car ownership, non-home ownership and household overcrowding expressed as a percentage of all households in a study area. The UK index of multiple deprivation combines information about income, unemployment, disability, education, skills, housing and crime and is available at super-output level (approximately 1500 residents). No consensus, however, has been reached regarding the optimal combination of these indicators in forming a universal index of socioeconomic status. For example, there is lack of standardization between different cultures as to whether social class should be quantified using maternal and paternal characteristics as opposed to maternal only characteristics [1]. Furthermore, it is known whether non-home ownership or non-car ownership necessarily reflect deprivation in a uniform manner across areas with different socioeconomic characteristics. An alternative method to measure socioeconomic status is to calculate the average values of the house prices in a specified area. This is easily accessible and free of charge from the Land Registry, the UK non-ministerial government department that registers the ownership of land and property in England and Wales [12]. The Sector House Average Price (SHAP) has the additional advantage that it can be assessed on a yearly basis and at a postcode sector level (corresponding approximately to 600 residents).

We hypothesised that areas with a lower SHAP would be associated with a lower gestational age at birth and lower birth weight and that SHAP would be lower for parents of infants that did not survive to discharge from the neonatal unit compared to the infants that did. Our aims were to test those hypotheses.

METHODS

Study design

An audit of all neonatal unit admissions between 1/1/2012 and 31/12/2016 at King's College Hospital NHS Foundation Trust (KCH), London was undertaken. KCH has a tertiary neonatal unit, approximately 6,000 deliveries per year and serves a diverse community of over 1,000,000 in south east London.

Data were extracted from the BadgerNet Neonatal Electronic Patient Record (Clevermed, Edinburgh, UK). Mortality was defined as death before discharge from neonatal care [13]. The following data were collected as possible confounders of mortality and morbidity [1]: maternal ethnic group (White, Mixed, Asian or Asian British, Black or Black British, Other) [14], maternal age (years), maternal smoking (yes/no), duration of rupture of membranes (hours), Apgar score at 5 minutes, gender, gestational age (weeks), prematurity (gestational age less than 37 completed weeks of gestation), birthweight (kg), birth weight centile, birth weight z-score, IUGR (defined as birth weight less than the tenth 10th centile), admission temperature (°C), admission blood glucose (mmol/L). The birthweight z-score and percentile was calculated based on locally derived birthweight reference ranges [15].

Sector House Average Price

The average price per postcode sector (Sector House Average Price-SHAP) of the house properties sold during 2016 was extracted from the "Price Paid" public open dataset from Her Majesty's Land Registry, UK [12]. Since adverse pregnancy outcomes in relation to socioeconomic factors rise sharply at the lower end of the social scale, the SHAP was divided in equal quintiles [2], with quintile one representing the highest SHAP (most expensive) and quintile five representing the lowest SHAP (least expensive).

Sample size calculation

We limited the period of our study to five years to ensure that provision of care did not change due to the introduction of new therapies. We thus included a sample size of 3,462 infants. A sample of 3,137 infants

enabled to detect a correlation of length of stay with the Sector House Average Price of 0.05 with 80% power at the 5% level.

Statistics

Data were tested for normality with the Kolmogorov Smirnov test. Normally distributed variables are presented as mean (standard deviation) and non-normally distributed variables are presented as median (interquartile range). The differences in SHAP, maternal age, duration of rupture of membranes, Apgar score at five minutes, gestational age, birthweight, admission temperature and admission glucose between the quintiles were tested with one-way ANOVA and the Bonferroni post hoc test, the Kruskal-Wallis U test and the Mann-Whitney U test as a post hoc test or with the χ^2 test. The factors that were significantly different between the quintiles of SHAP were inserted in a multivariate linear regression model with the gestational age as the outcome variable. Non-normally distributed variables were logarithmically transformed.

Differences between infants who survived compared to those who died were assessed using the Student's t-test, the Mann-Whitney U test or the χ^2 test as appropriate. The factors that were significantly different between the infants who survived or died were inserted in a binary multivariate regression model with survival to discharge as the outcome variable.

Multi-collinearity among the independent variables in the regression analysis was assessed by calculation of the tolerance for the independent variables. Statistical analysis was performed using SPSS software (IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY: IBM Corp.)

RESULTS

From 1/1/2012 to 31/12/2016, 3,462 infants were admitted to the neonatal unit. One hundred and two infants were excluded from the study as their postcode data were not available or they were from overseas. Three thousand three hundred and sixty infants were included in the study. Each quintile contained 672 infants (Table 1).

The mothers of the infants in quintile five were younger ($p<0.001$) and a greater proportion had received antenatal steroids ($p<0.001$) than the mothers in all the other quintiles. The infants in quintile five had significantly lower Apgar scores at five minutes ($p<0.001$), a lower gestational age and birthweight and a longer

duration of stay compared to the infants in all the other quintiles ($p<0.001$). The infants of quantile five had higher admission blood glucoses ($p<0.001$) and higher mortality compared to the infants in all the other quintiles ($p<0.001$). There were no significant differences in the ethnic origins of the mothers between the quintiles (Table 2). Following multivariate linear regression analysis, gestational age was significantly lower in quintile five after adjusting for maternal age and maternal smoking (adjusted $p<0.001$). Birthweight was not included in the multivariate model because of collinearity with gestational age in the absence of a significant difference in birth weight z-score between the quintiles.

Three thousand two hundred and sixty-eight of the infants were alive at discharge and 92 had died (2.7 %). The deceased infants had a lower SHAP ($p<0.001$), Apgar score at five minutes ($p<0.001$), gestational age ($p<0.001$), birth weight ($p<0.001$), admission temperature ($p<0.001$) and admission blood sugar ($p<0.001$) (Table 3).

Forty-seven infants of mothers from a white ethnic background (3.0 %), two infants of mothers of mixed ethnicity (1.9 %), eight infants of mothers of Asian background (3.8 %), 33 infants of mothers of black background (3.0 %) and one infant of a mother of Chinese background (0.6 %) died. There was no significant difference in mortality across infants of different ethnic groups ($p=0.397$). Following multivariate binary regression analysis SHAP, Apgar score at five minutes, gestational age, admission temperature and admission blood glucose were independently associated with mortality (Table 4). Birth weight was excluded from the model due to collinearity with gestational age and the absence of a significant difference in birth weight z-score between the deceased infants versus the infants that survived.

DISCUSSION

We have demonstrated that infants whose mothers live in the least expensive quintile of houses delivered more prematurely and had a higher mortality compared to infants from all the other quintiles. Our results are in agreement with previous studies which have highlighted that lower socioeconomic status was associated with a higher incidence of prematurity [1, 6, 17] and neonatal mortality [18-20]. These results have been replicated in other countries [2, 21-23] using composite deprivation indices. Our study is the first to use house prices as an index of socio-economic status in a neonatal population and highlights that SHAP could be used as simple, easily derived epidemiological index of deprivation.

In our study, low birth weight z-score and IUGR were not associated with the average house prices. This is in contrast to a number of older studies which demonstrated a poorer socioeconomic background was associated with low birthweight [16, 24-26]. The majority of the previous studies, however, did not adjust for gestational age [16, 24-26], so possibly, the low birth weight was a reflection of prematurity. One study that did adjust for low gestational age reported a relative risk of only 1.2 for a birth weight less than the tenth centile in quintile five versus the other quintiles [27].

Our study has a number of strengths and some limitations. While other studies have considered prematurity and low birthweight as binary outcomes with cut-offs at 37 weeks of gestation and 2.5 kg respectively, we considered gestational age and birthweight as continuous outcomes. Treating those factors as continuous rather than binary outcomes is methodologically advantageous in view of the growing body of evidence that describes late preterm morbidity [28]. In addition, birth weight cut-off values might not describe accurately nutritional and growth deficiencies in the developing fetus [29]. While other composite indices have been used to describe socioeconomic deprivation, they are derived on a 10-yearly Census basis. In contrast SHAP can be derived on a yearly basis and corresponds to a smaller output area even than the latest-used UK multiple deprivation index [1]. Finally, the SHAP is a customizable index that can be derived upon request for even smaller periods of time (e.g. three months), albeit then the sample size on which the average price is calculated upon would be considerably smaller and prone to sampling error. A limitation of our study was it was a single-centre study, but it included a diverse multi ethnic population.

The applicability of this study lies in that the SHAP could be used as an alternative deprivation index and outcome measure to quantify the effect of interventions at a specific area-level on maternal health. Policymakers and governing bodies could thus identify specific postcode sectors of deprivation and implement targeted interventions to improve maternal health and reduce inequalities in neonatal morbidity [1].

In conclusion, we have described that mothers living in the least expensive quintile of houses are more likely to have premature birth and their infants to have a higher mortality than the infants born to mothers living in the more expensive quintiles of houses. Our results suggest SHAP could be used in perinatal populations to determine socio-economic status and associate outcomes.

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Competing interests: The authors declare no conflict of interest.

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